

Measuring Fault Parameters and Slip from Geodetic Imaging Data using GeoGateway Online Tools

**Geological Society of America 2020 Workshop
NASA Data Made Easy: Getting Started with Synthetic Aperture Radar**

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GeoGateway Overview

- Online tools for analysis, modeling, and response using geodetic imaging data
- Main application of GeoGateway is to analyze and model crustal deformation related to earthquakes, and measure fault slip
- Focus of tools
 - Airborne InSAR data from NASA's airborne UAVSAR platform
 - Global Navigation Satellite System (GNSS) position time series, displacements, and velocities
- Other tools
 - Data layering
 - Faults
 - Seismicity
 - Forecasting
 - Modeling



Data types and products

UAVSAR: NASA's L-band InSAR platform

- cm level detection of surface deformation
- Has measured
 - Landslides
 - Levees
 - Subsidence
 - Earthquakes
 - Volcanoes
 - Wildfire scars
 - Glaciers



GNSS: Global Navigation Satellite System

- Precise position time series
- Daily to sub-daily solutions
- Accuracies are sub-mm globally
- Provide rates to better than 1 mm/yr
- Limitations
 - Stations widely separated by 10 km or more
 - Difficult to infer smaller scale processes

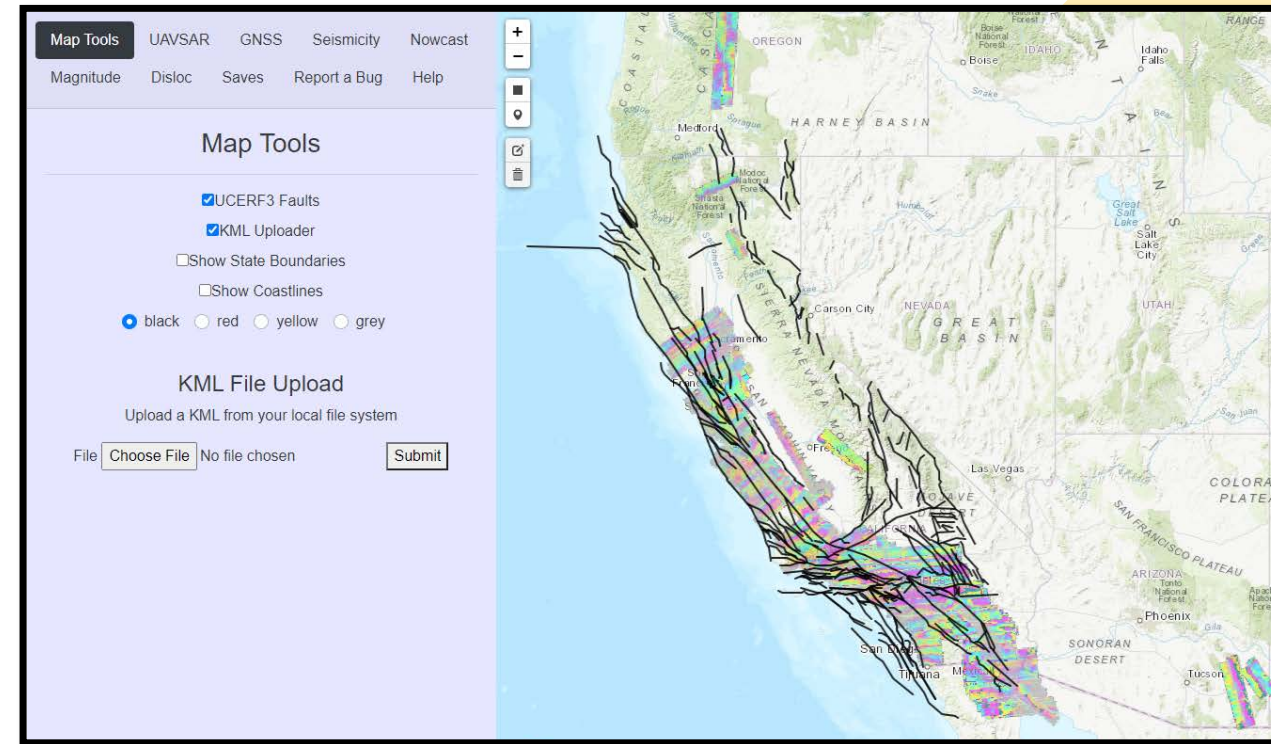


Other Data Products

- UCERF-3 faults
- Seismicity
- User generated KML overlays

Geographic Coverage

- Global
- Focus on California
 - Majority of UAVSAR flights
 - UCERF-3 digitized faults
 - Abundance of GNSS stations
 - Dense Seismic Network



Limitations

Limitations

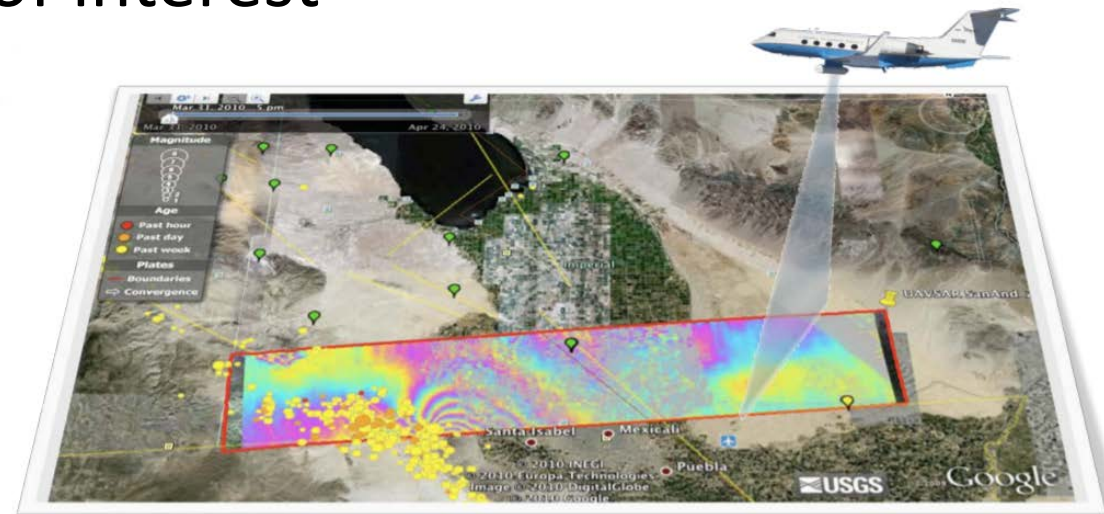
- Advantages:
 - Designed for rapid analysis of geodetic imaging data
 - Allows for context from other data types
- Not suitable for full analysis
 - Can download products for further analysis
- Uncertainty quantification is limited
- No stacking of InSAR products (yet)
- User workspace is limited (so far)
- Possible bugs – please file feedback reports!



Uninhabited Aerial Vehicle Synthetic Aperture Radar

UAVSAR

- An airborne, L-band, fully polarimetric radar, housed in a pod that is mounted to the belly of a piloted Gulfstream III aircraft
- Interferometric radar images, or interferograms, are generated from repeat passes flown over a site of interest
- Interferometric radar observations are made from the swaths received, which are approximately 22 km wide and typically between 100 and 300 km long



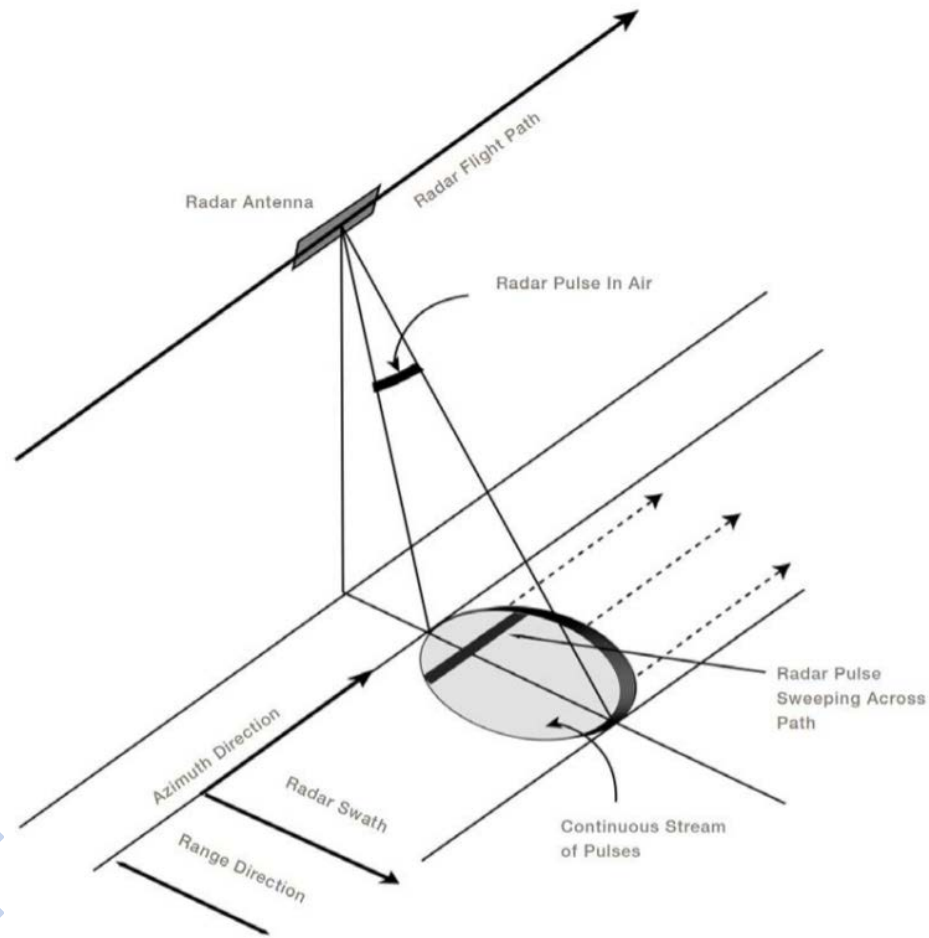
Basic InSAR Concepts

Basic InSAR concepts

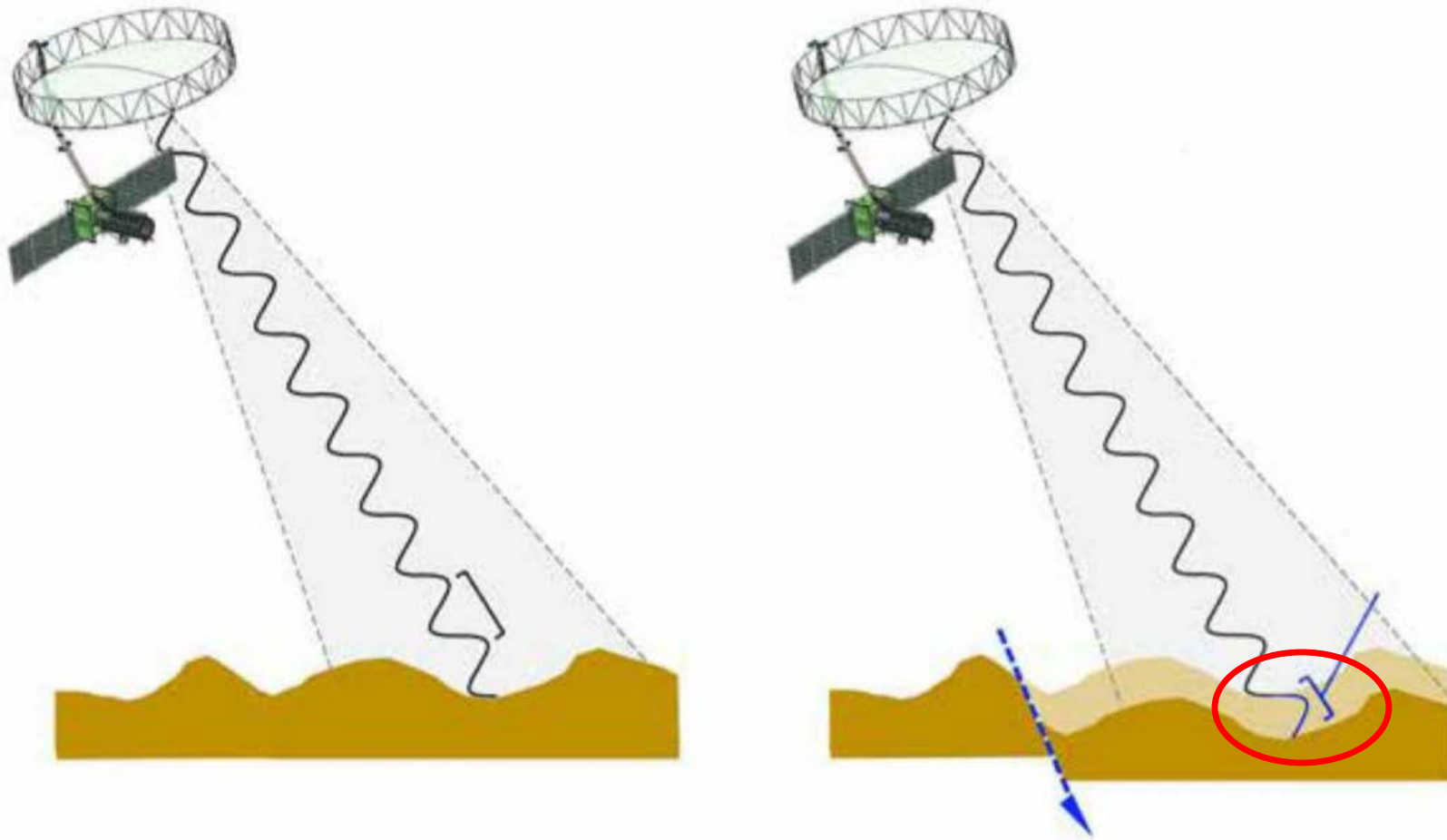
- Selecting data products
- Displaying individual lines
- Color mapping
- Line of sight tool
- Downloading products
- Example from User Guide



Synthetic Aperture Radar

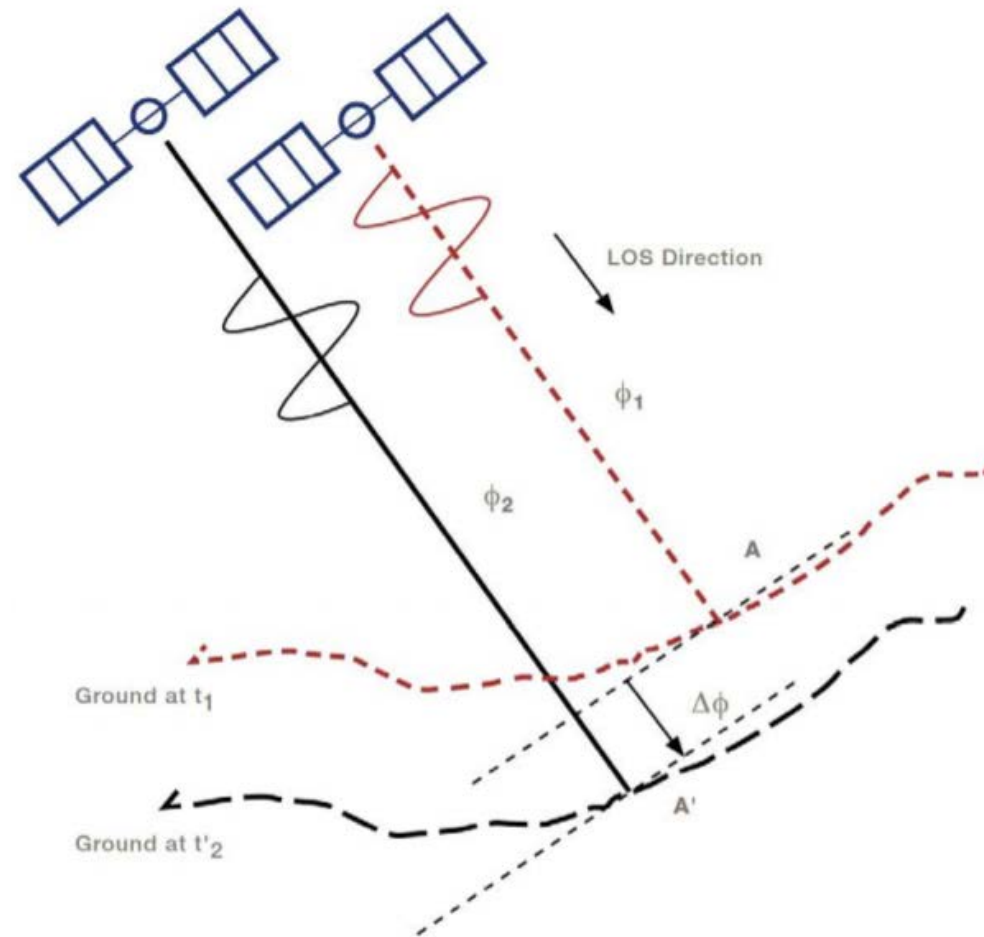


InSAR Phase Difference

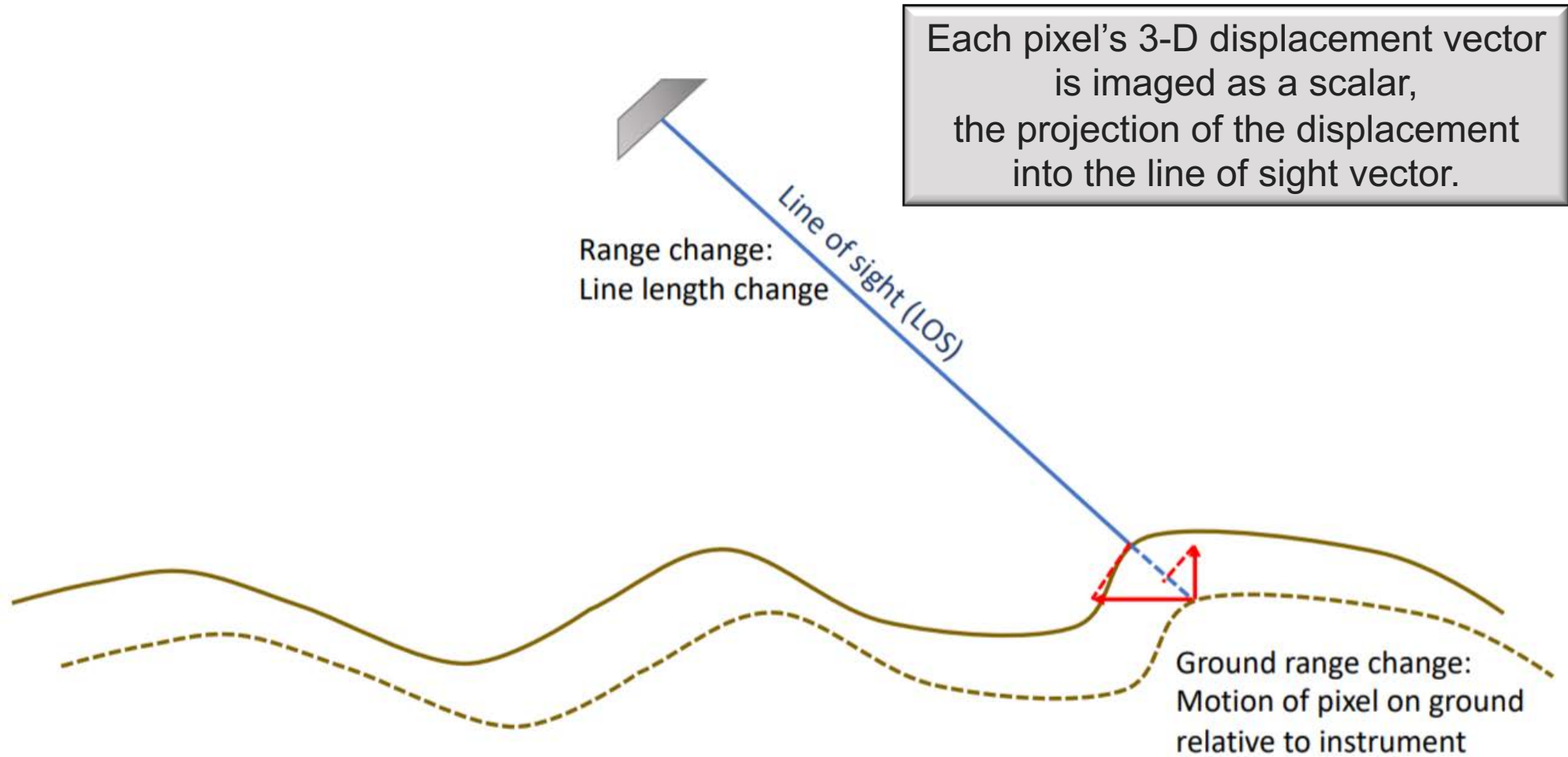


Phase Difference

- UAVSAR raw image pairs 1 m resolution
- UAVSAR unwrapped products 7 m



Line of sight (LOS)

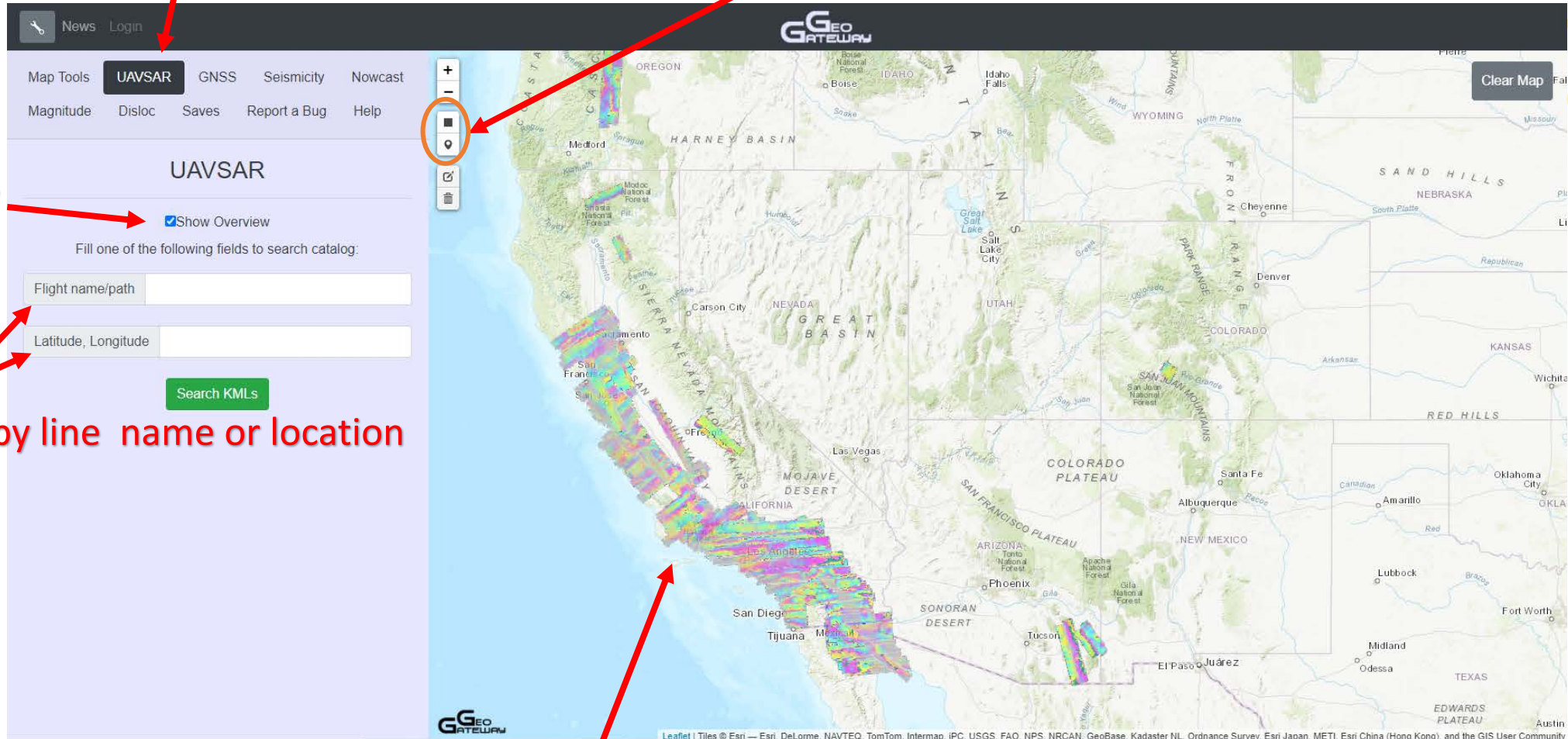


Select Data Products

1. Click on UAVSAR tab

4a. Select by point or rectangle

2. Check
Show
Overview



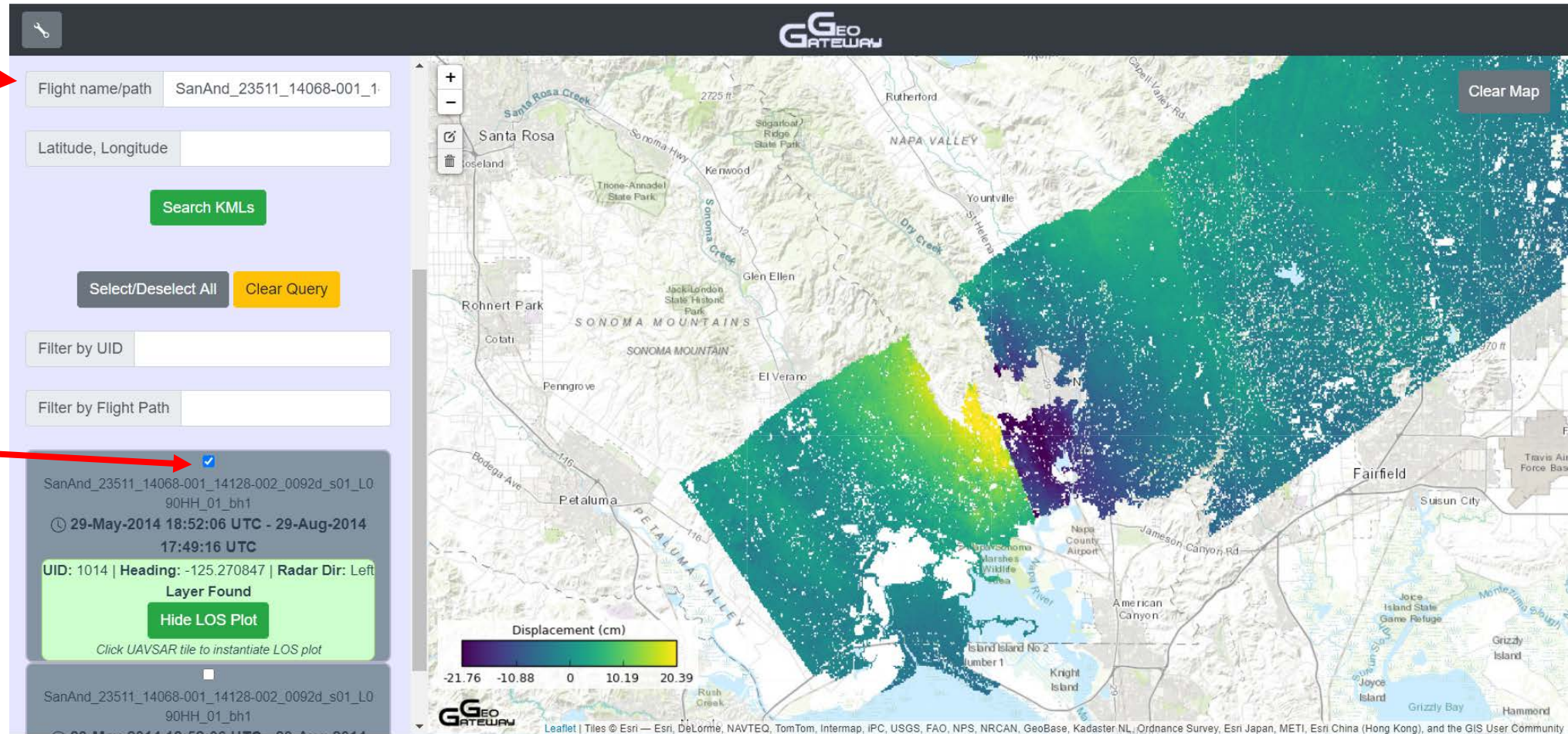
4b. Select by line name or location

3. Available products are displayed

Displaying Individual Lines

Select by flight
name/path →

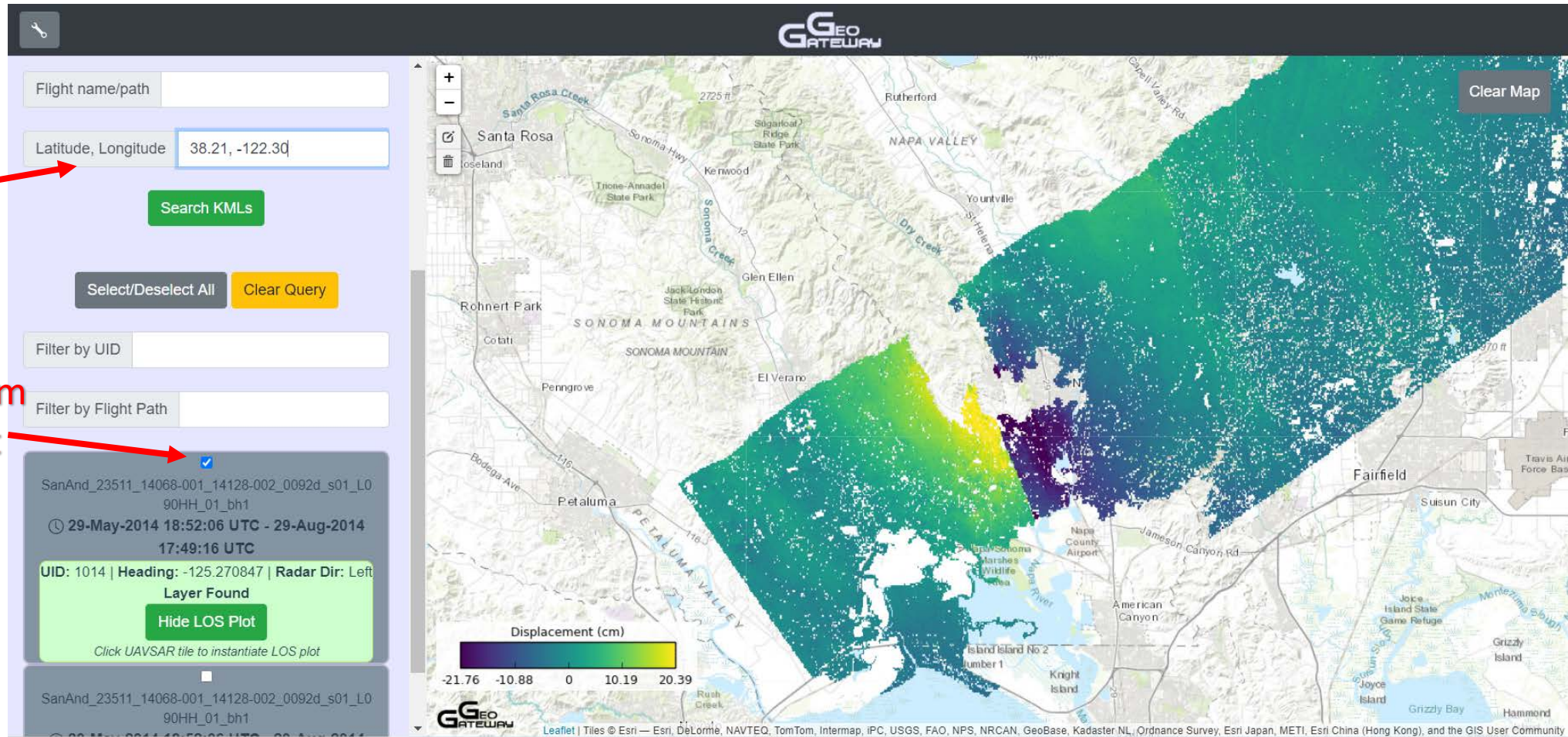
Select
Interferogram
of interest →



Displaying Individual Lines

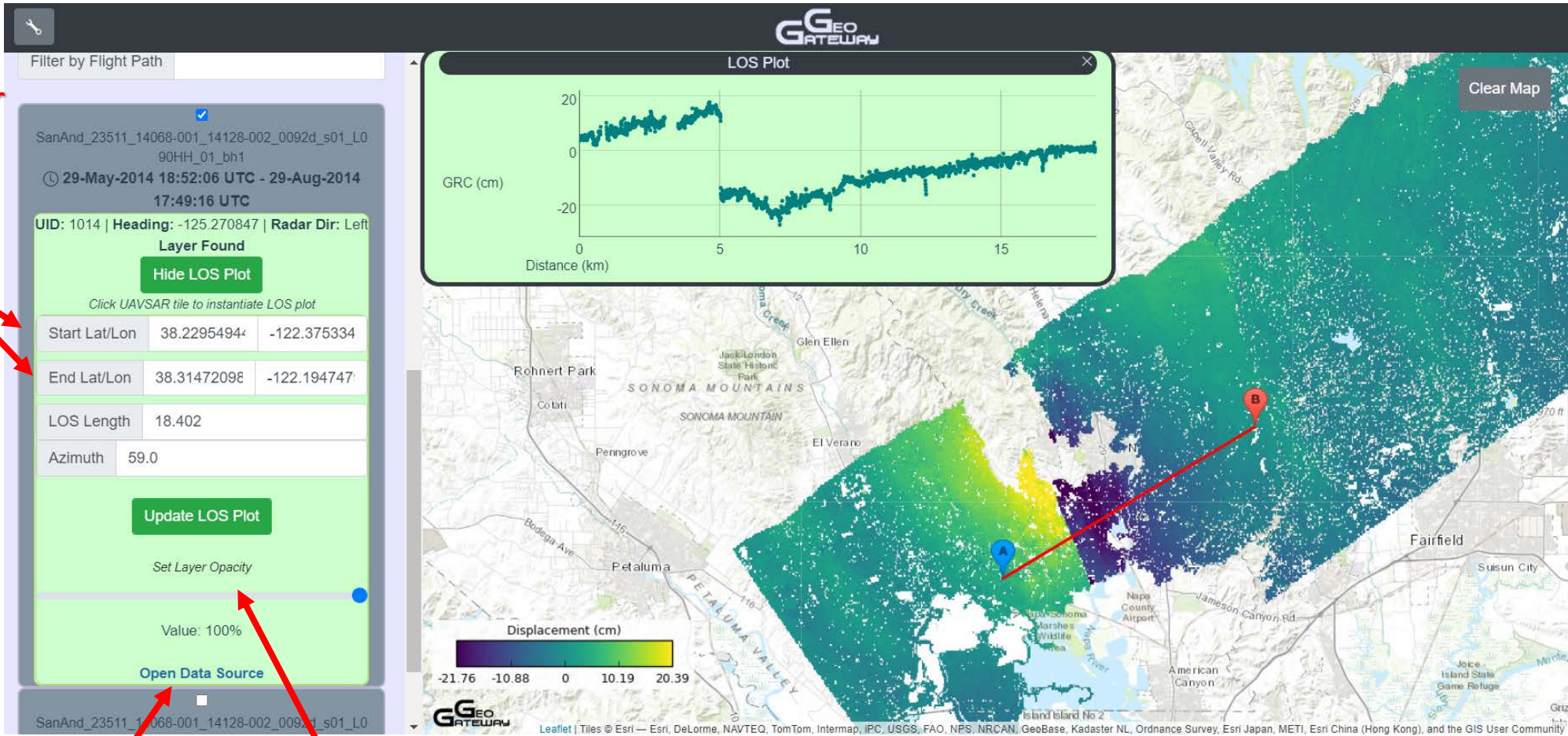
Select by
Latitude &
longitude

Click on
interferogram
of interest



Line of Sight Tool

Change
parameters for
interferogram
start and end
points



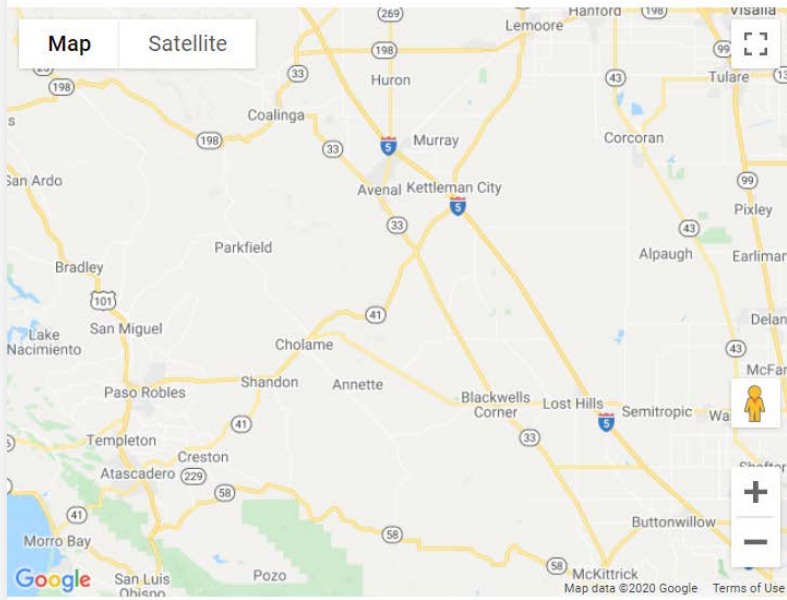
Download
data

Set layer
opacity

Downloading Products

SanAnd_26501_09083-010_10028-000_0174d_s01_L090HH_C2

- **Description:** San Andreas Fault - Salton Trough, CA
- **Time1:** 21-Oct-2009 00:21:20 UTC
- **Time2:** 13-Apr-2010 17:39:51 UTC
- **Lines:** 6404
- **Samples:** 20529
- **Terrain Height:** 59.736268
- **GPS Altitude:** 12495.0015
- **Peg Head:** -95.326483
- **Peg Lon:** -115.538897
- **Peg Lat:** 32.903278
- **Radar Direction:** Left
- **Radar Wavelength:** 23.840355



Data Source: NASA JPL Data Center

The NASA data archive at ASF now requires [user login](#)

Metadata

- [Metadata](#)
- [Data format](#)

Slant range Products

- [Slant range interferogram](#)
- [Slant range unwrapped phase](#)
- [Slant range correlation](#)
- [Slant range amplitude 1](#)
- [Slant range amplitude 2](#)

Ground range Products

- [Ground range interferogram](#)
- [Ground range unwrapped phase](#)
- [Ground range correlation](#)
- [Ground range amplitude 1](#)
- [Ground range amplitude 2](#)
- [DEM used in ground projection](#)

KMZ of Ground Range Products

- [KMZ of Ground range interferogram](#)
- [KMZ of Ground range unwrapped phase](#)
- [KMZ of Ground range correlation](#)
- [KMZ of Ground range amplitude 1](#)
- [KMZ of Ground range amplitude 2](#)
- [KMZ of DEM used in ground projection](#)

Downloading Products - UAVSAR

EARTHDATA LOGIN

ALASKA SATELLITE FACILITY

ASF makes remote sensing data accessible.

Username

Password

☒ **Stay signed in (this is a private workstation)**

LOG IN **REGISTER**

[I don't remember my username](#)
[I don't remember my password](#)
[Help](#)

Why must I register?

The Earthdata Login provides a single mechanism for user registration and profile management for all EOSDIS system components (DAACs, Tools, Services). Your Earthdata login also helps the EOSDIS program better understand the usage of EOSDIS services to improve user experience through customization of tools and improvement of services.

EARTHDATA LOGIN

Redirecting

You are already logged in, and we are redirecting you to the application.

If you are not redirected, click the button below.

REDIRECT TO APPLICATION

Opening SanAnd_26501_10028-000_10057-100_0079d_s01...

You have chosen to open:

...1_10028-000_10057-100_0079d_s01_L090HH_01.int.kmz
which is: Google Earth KMZ Document (88.0 MB)
from: <https://uavsar.asfdaac.alaska.edu>

What should Firefox do with this file?

☐ Open with Google Earth Pro (default)

☒ Save File

☐ Do this automatically for files like this from now on.

Cancel **OK**

For questions regarding the EOSDIS Earthdata Login, please contact [Earthdata Support](#)

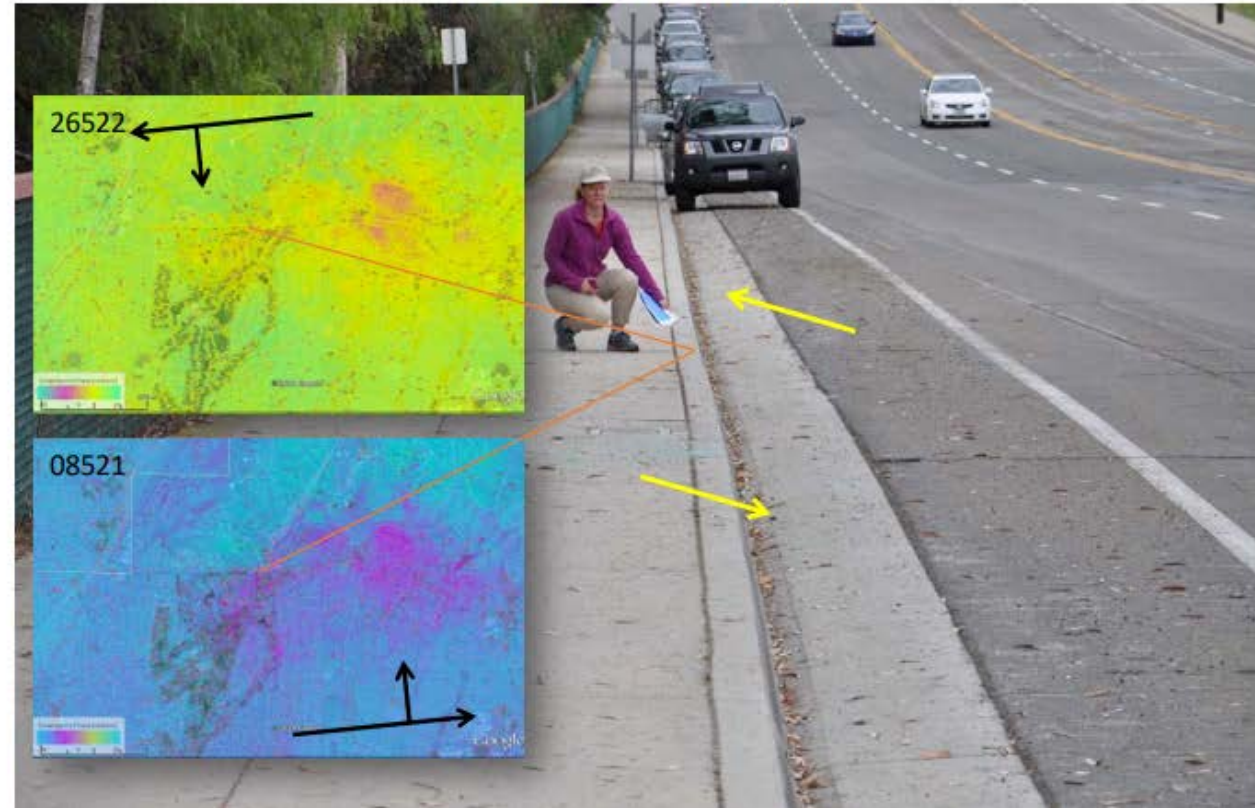
V 4.95 [Home](#) [Register](#) [Documentation](#) [NASA](#)

NASA Official: Stephen Berrick

Location Awareness – Useful in the field

- Show location option under map tools is a feature that will be available shortly

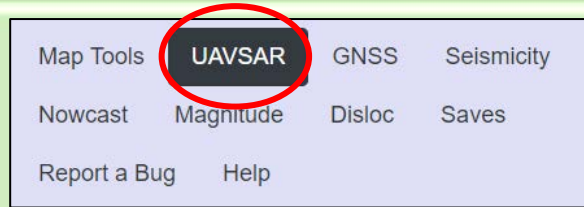
La Habra earthquake



UAVSAR - Example

Step 1: Visit [website](#)

Step 2: Click on the
“UAVSAR” tab



Step 3: Check “show overview”

☒ Show Overview

UAVSAR - Example

Step 4: Search for an interferogram (choose one of the following options)

1. The “flight name/path” directly finds the flight name and path wanted
2. The “latitude, longitude” option returns all flight paths crossing paths with those coordinates. In the case of this exercise, enter 26501 (flight name/path) in the search window and hit return


Flight name/path


option 1

Latitude, Longitude

option 2

*Note options to draw an area or drop a pin can assist users to finding an interferogram

 Draw Area

 Drop Pin

UAVSAR - Example

Step 5: Select the second interferogram & click on the interferogram shown on the map to activate the LOS tool.

The screenshot displays the UAVSAR web interface. On the left, there is a search and filter panel. The 'Flight name/path' field contains '26501'. Below it are fields for 'Latitude, Longitude', a 'Search KMLs' button, and buttons for 'Select/Deselect All' and 'Clear Query'. Further down are filters for 'Filter by UID' and 'Filter by Flight Path'. A list of flight data is shown, with the second entry selected (indicated by a blue checkmark and a red circle):

Flight Name/Path	Timestamp
SanAnd_26501_10028-000_10057-100_0079d_s01_L090HH_01	13-Apr-2010 17:39:51 UTC - 01-Jul-2010 16:42:33 UTC
SanAnd_26501_09083-010_10028-000_0174d_s01_L090HH_C2	21-Oct-2009 00:21:20 UTC - 13-Apr-2010 17:39:51 UTC

Below the selected entry, a green box displays the following information:

UID: 258 | Heading: -95.326483 | Radar Dir: Left
Layer Found
Hide LOS Plot
Click UAVSAR tile to instantiate LOS plot

On the right, a map of the Imperial Valley area is shown. A red arrow points from the text 'click on the interferogram shown on the map' to a green rectangular area on the map, which corresponds to the selected flight data. The map includes labels for the Salton Sea, Colorado River, Colorado Canal, Imperial Valley, and various locations like Mexicali and San Luis Rio Colorado. A color scale for 'Displacement (cm)' is provided at the bottom of the map, ranging from -54.76 to 13.86.

UAVSAR - Example

Step 6: Input the latitude and longitude for the starting (A) and ending (B) points for the LOS.

Note the “Set Layer Opacity” option, allows for users to increase or decrease the value for opacity of the interferogram.

SanAnd_26501_09083-010_10028-000_0174d_s01_L0
90HH_C2
21-Oct-2009 00:21:20 UTC - 13-Apr-2010
17:39:51 UTC

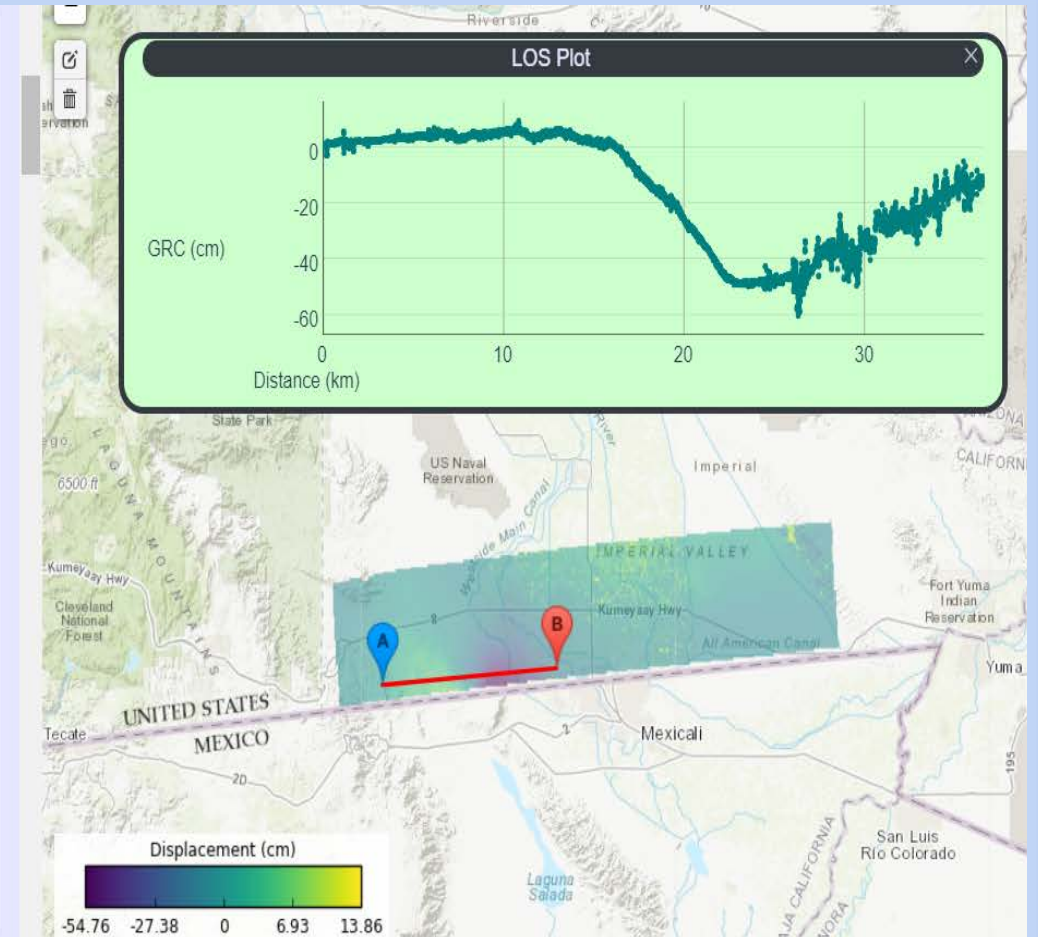
UID: 258 | Heading: -95.326483 | Radar Dir: Left
Layer Found
Hide LOS Plot
Click UAVSAR tile to instantiate LOS plot

Start Lat/Lon	32.66017314	-115.968933
End Lat/Lon	32.68561052	-115.5789201
LOS Length	36.625	
Azimuth	85.6	

Update LOS Plot

Set Layer Opacity
Value: 50%

Open Data Source



Global Navigation Satellite System (GNSS) Tools

- EMC: Velocity
- Coseismic
- Postseismic
- Displacement
- Model
- Reference station
- Product download



GNSS Tools

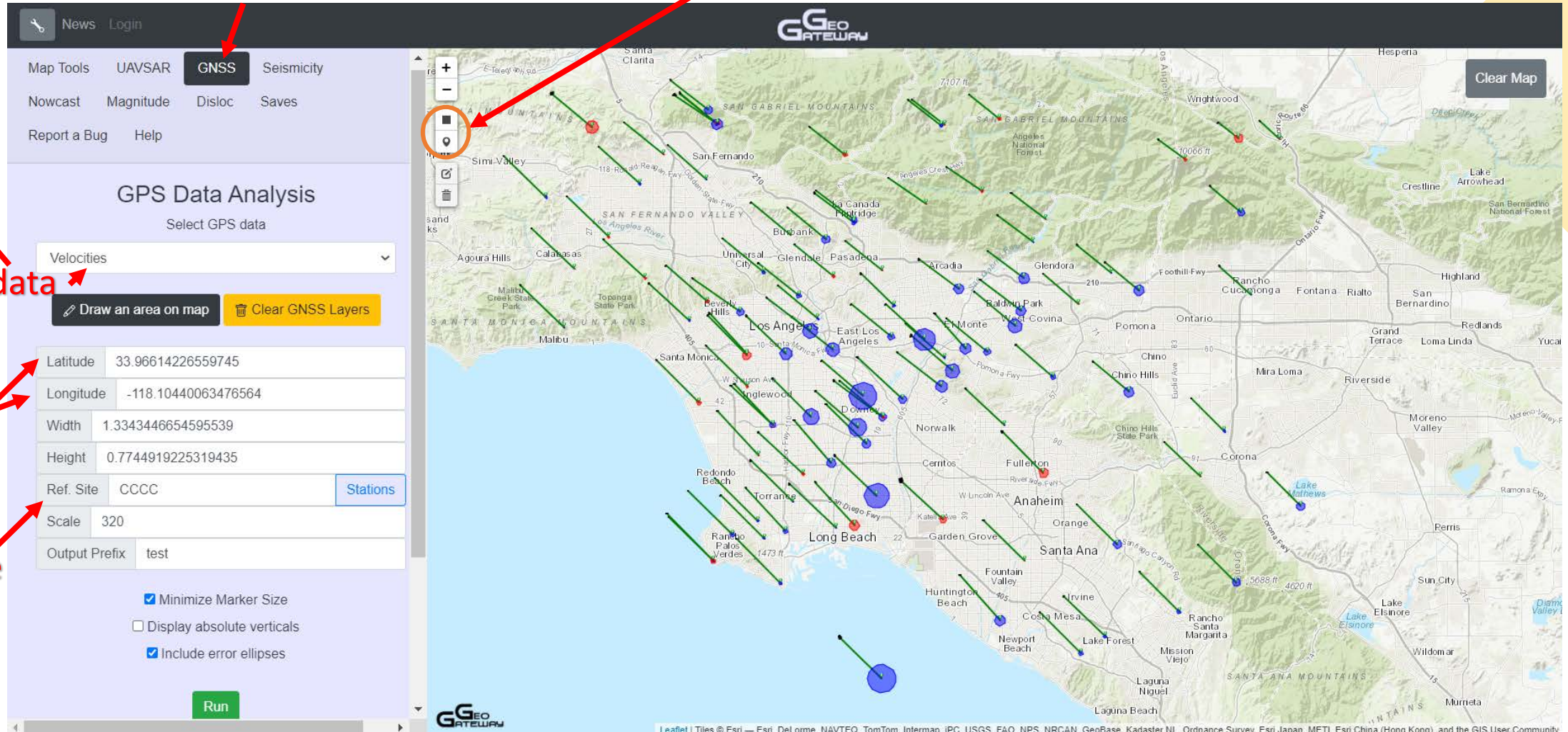
1. Click on GNSS tab

3a. Select by point or rectangle

2. Select GPS data

3b. Select by location

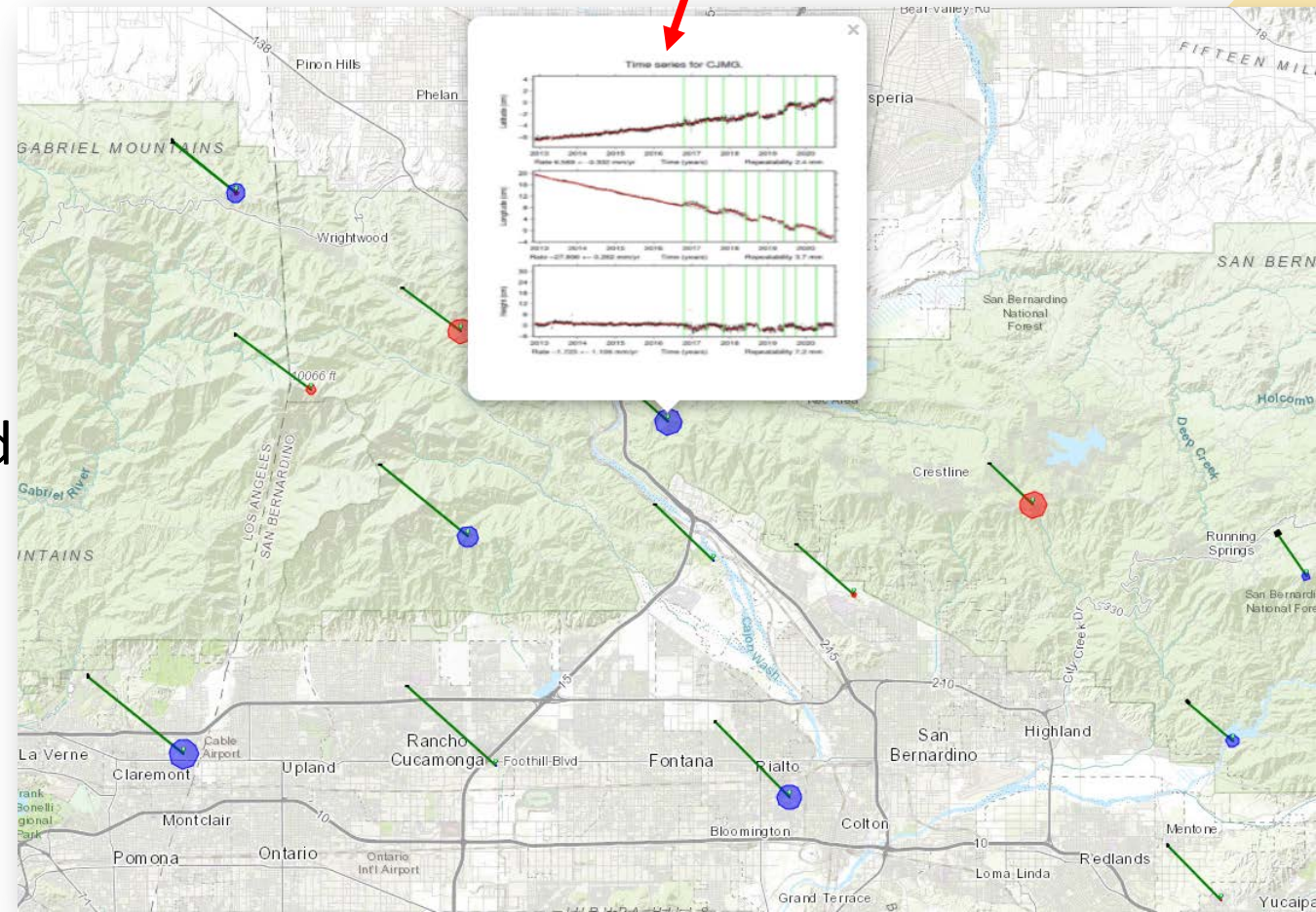
4. Reference site



GNSS Tools

- Each vector shows the velocity of a single GPS station
- Length of the vector shows how fast the GPS station is moving
- Vertical displacement is shown by red (uplift) or blue (subsidence) circles
- The larger the circle the greater the displacement

Click on a GPS station to view the time series' graphs



GNSS Time Series

top graph shows latitude (cm) versus time (years)

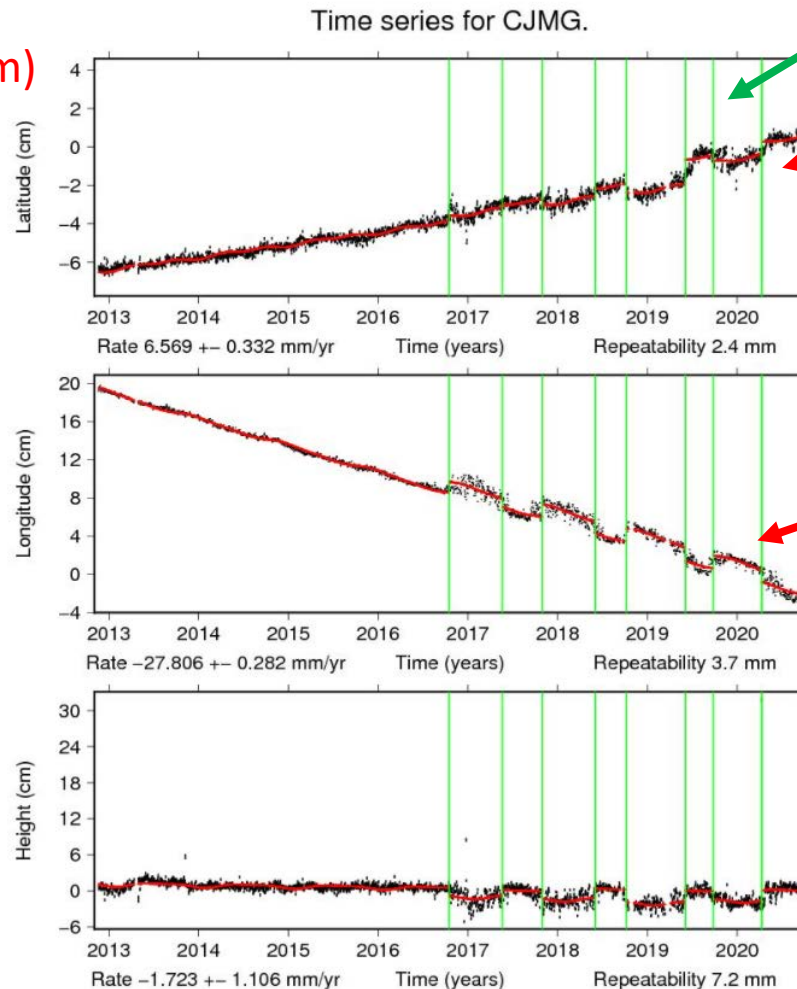
Middle graph shows longitude (cm) versus time (years)

Bottom graph shows the vertical height (cm) versus time (years) which is relatively constant

Vertical intersecting green lines are locations where there are jumps in the data

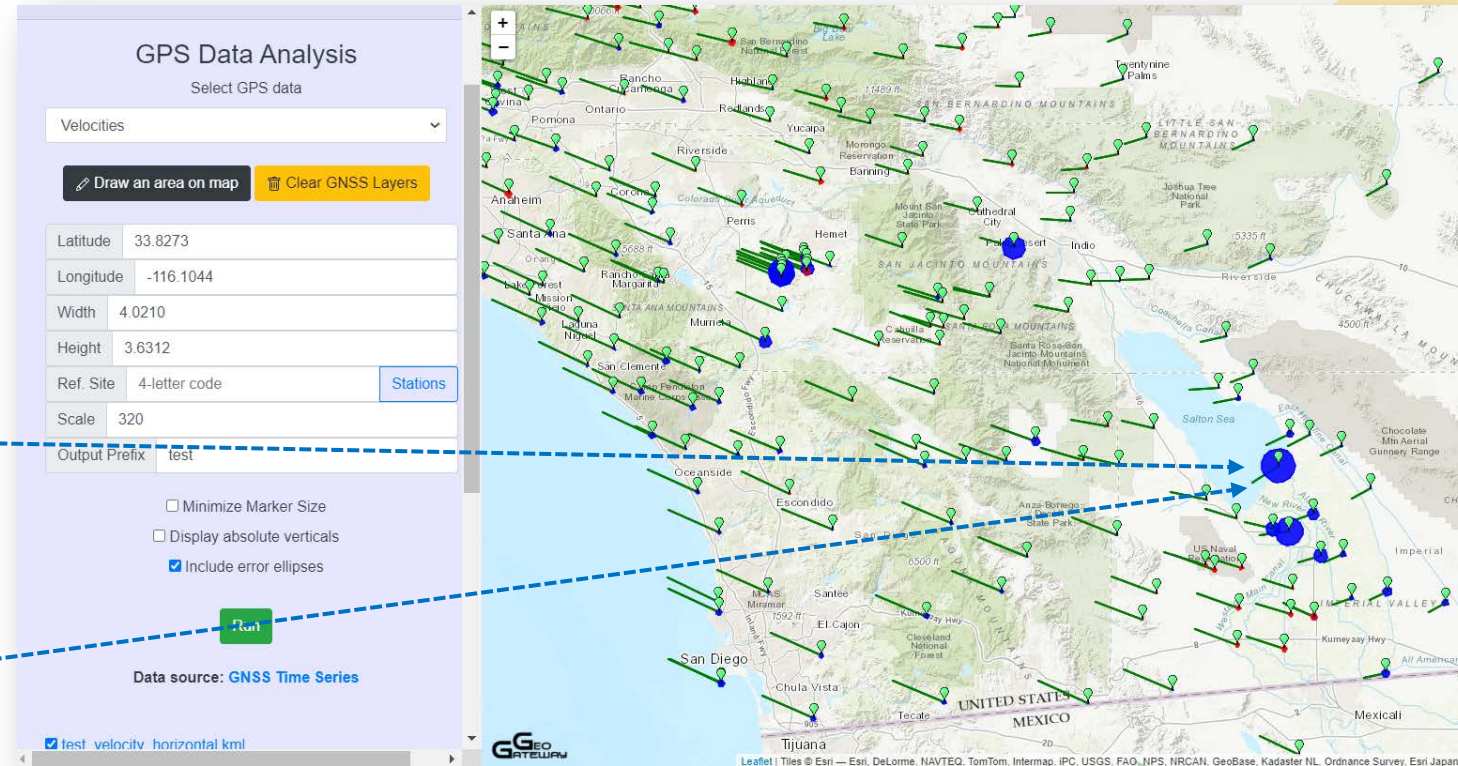
In the top graph, the station moves closer to the North with time

In the middle graph, the station is moving to the West with time

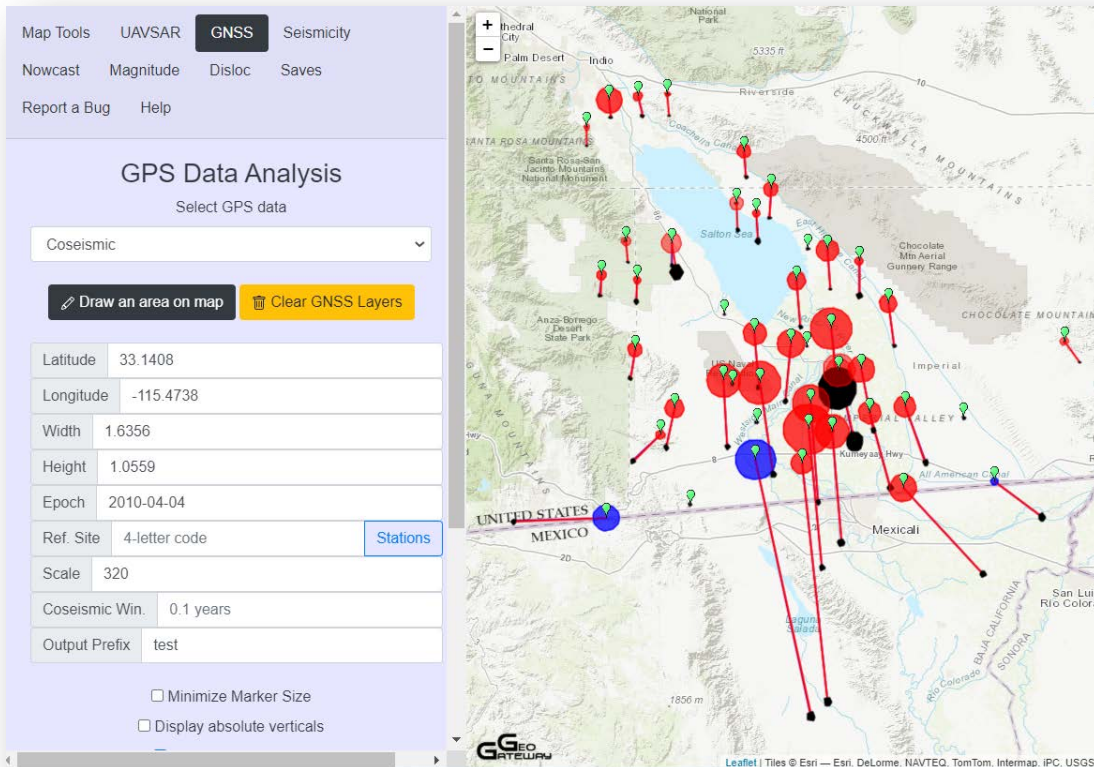


GNSS - Velocity

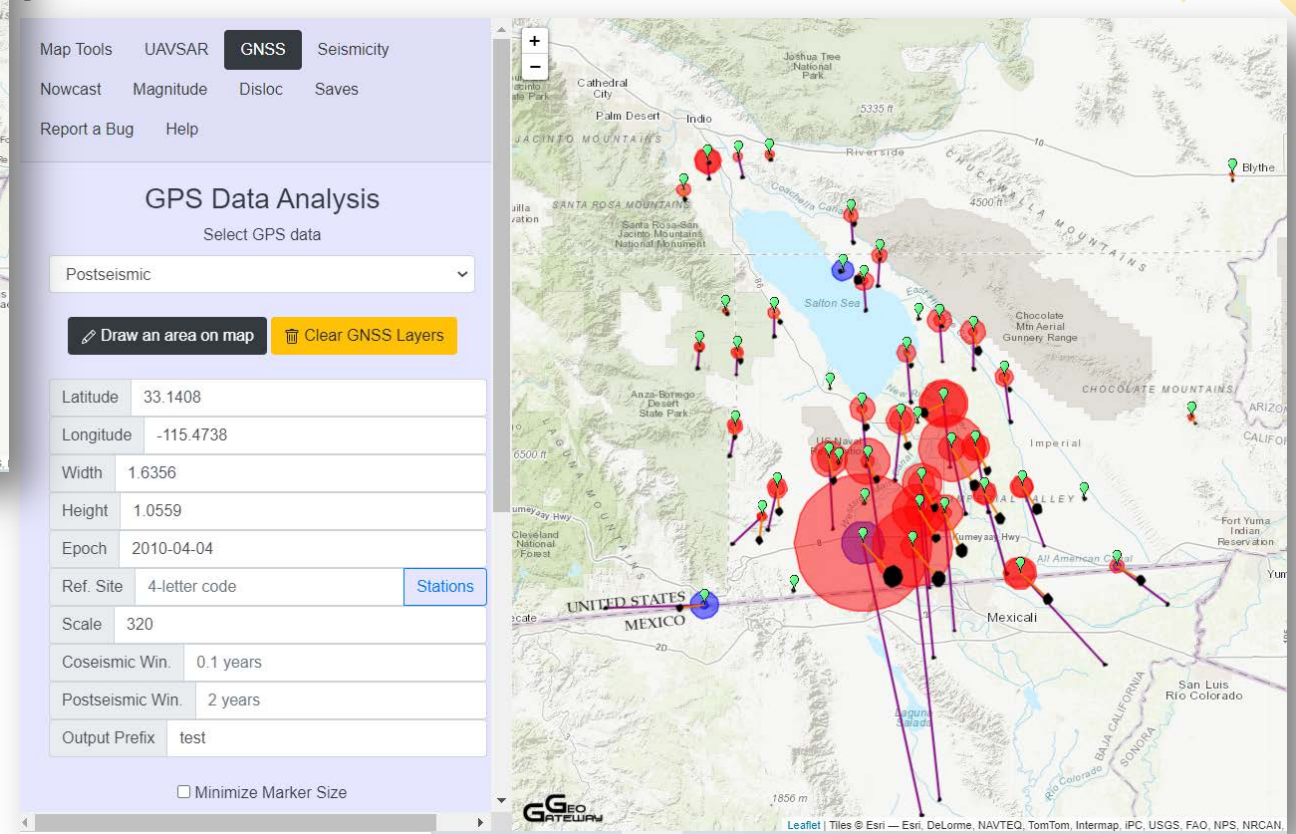
- The velocity vectors are shown as green vectors with error ellipses
- Vertical displacement is shown by red (uplift) or blue (subsidence) circles
- The larger the circle the greater the displacement



GNSS – Coseismic & Postseismic

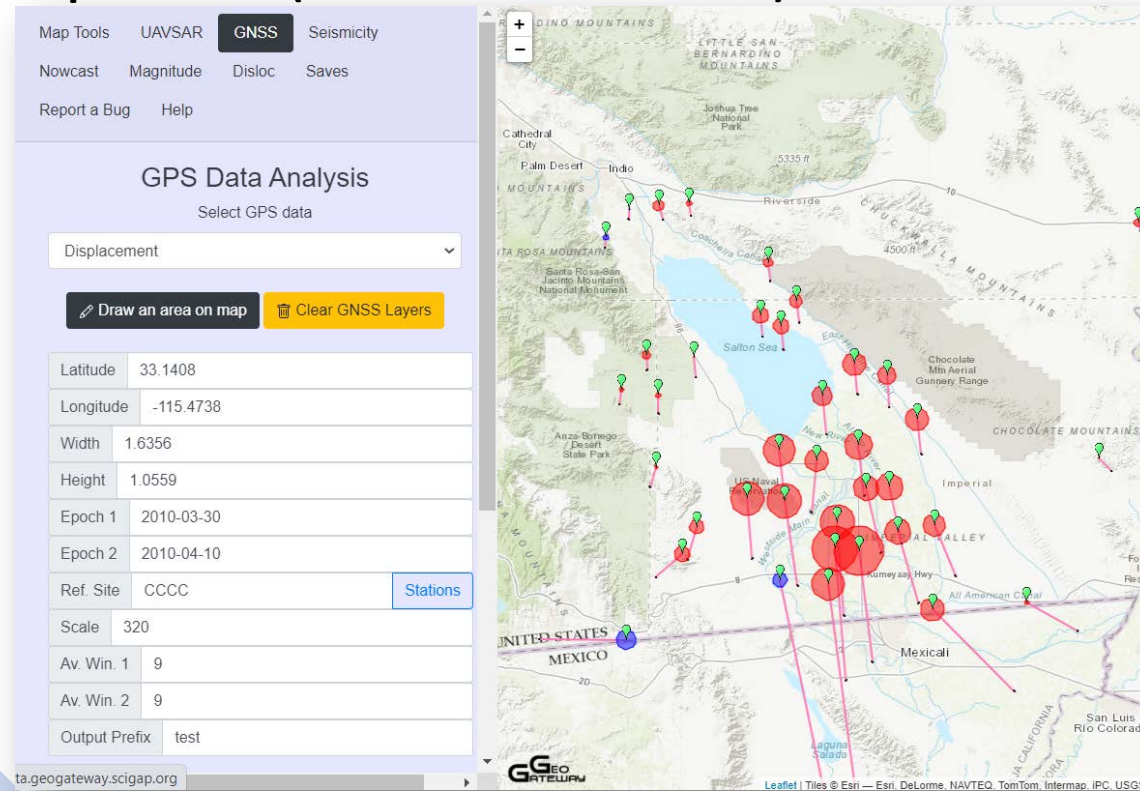


postseismic

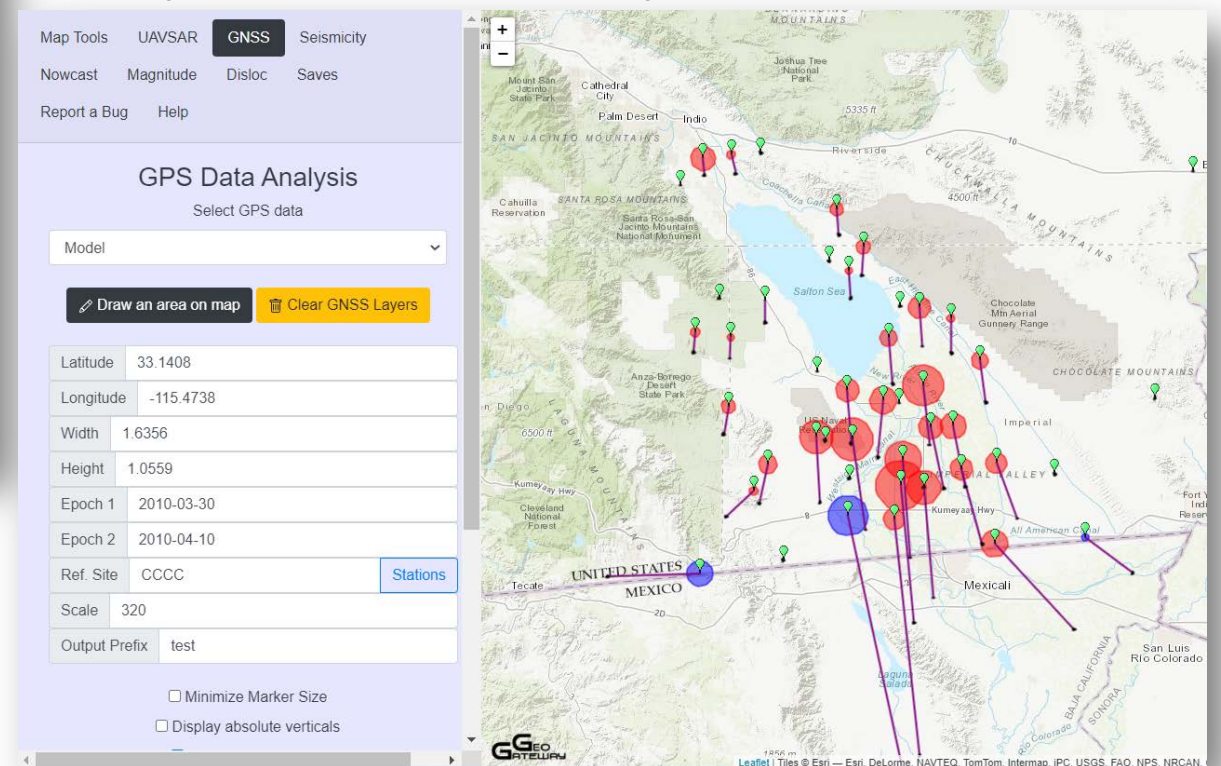


GNSS – Displacement & Model

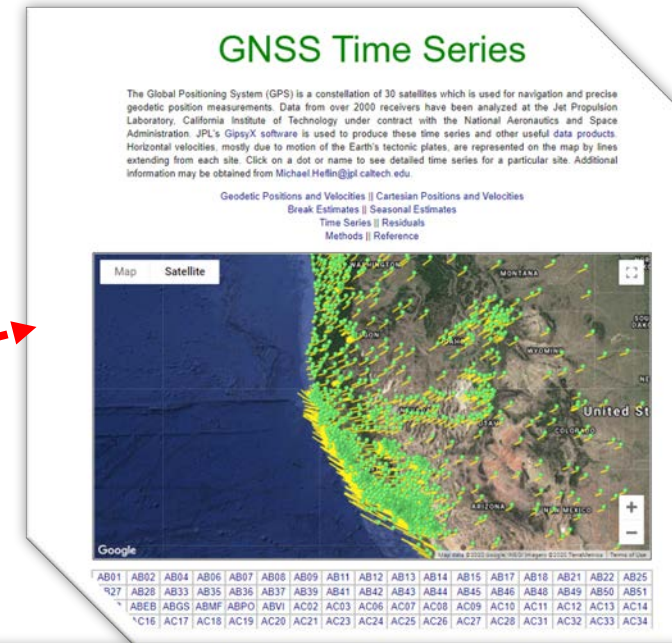
Displacement (alternative to coseismic)



Model (alternative to coseismic)



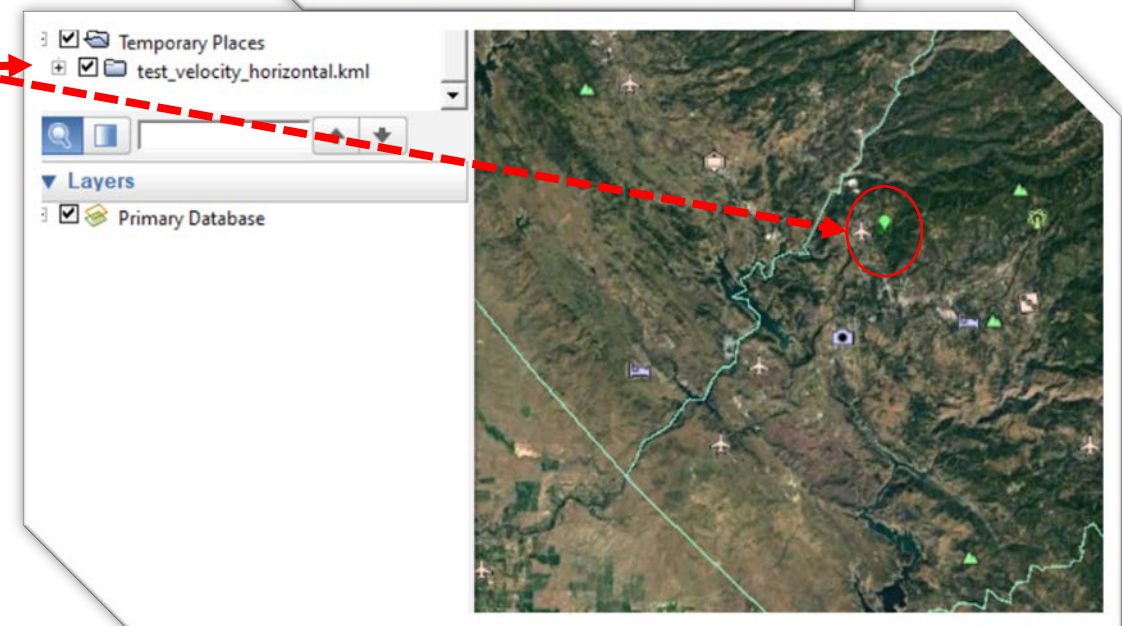
GNSS –Download Data



Data source: **GNSS Time Series**

☒ test_velocity_horizontal.kml

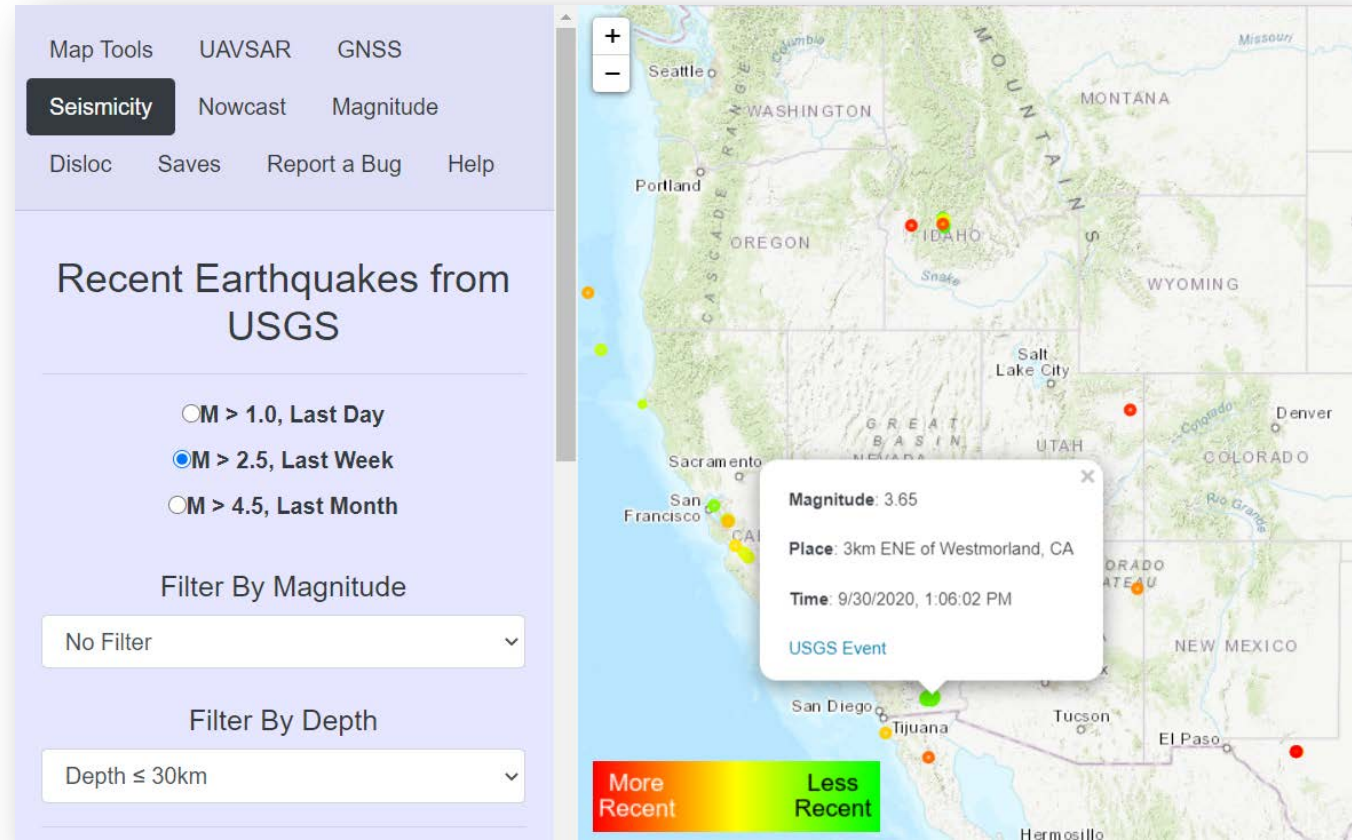
☒ test_velocity_vertical.kml



Seismicity

First Feature:

- Display seismic data from USGS feeds.
- Color coded for age of event, **cooler colors** for earlier events, **hotter colors** for later events.
- Event size corresponds to magnitude.
- Click on event for tooltips.



Seismicity

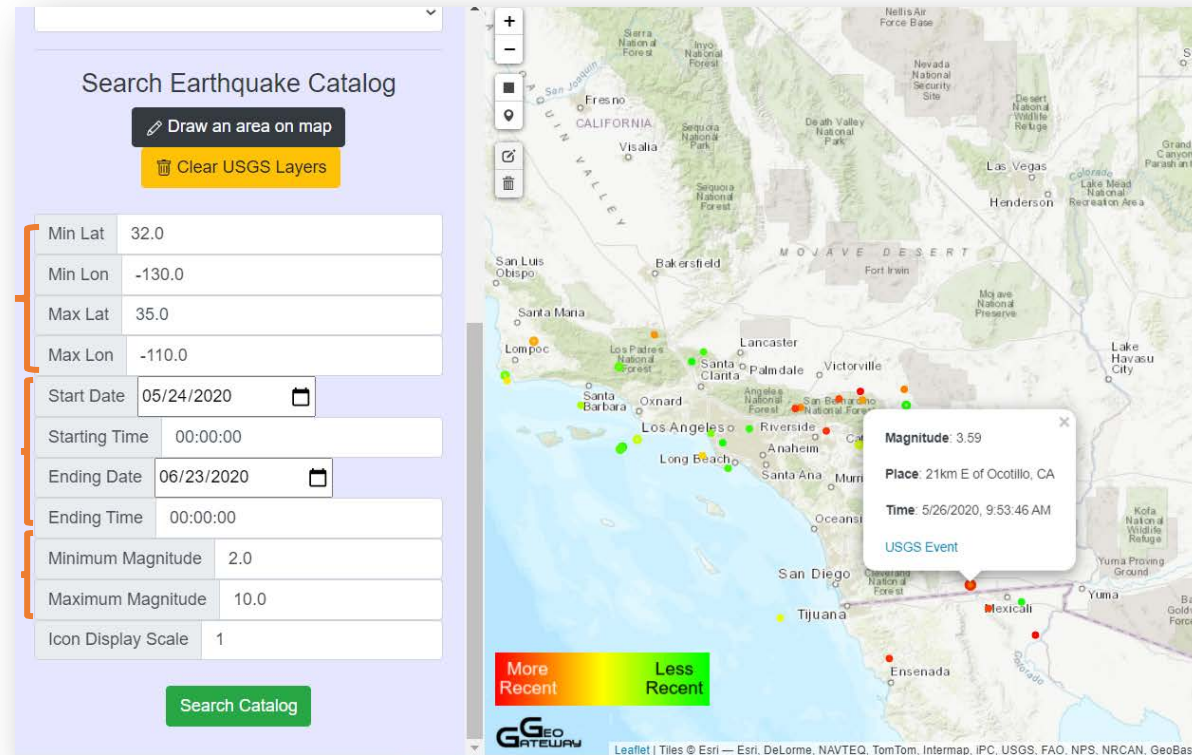
Second Feature:

- Filter to display seismic data from USGS feeds.

1. Insert latitude and longitude →

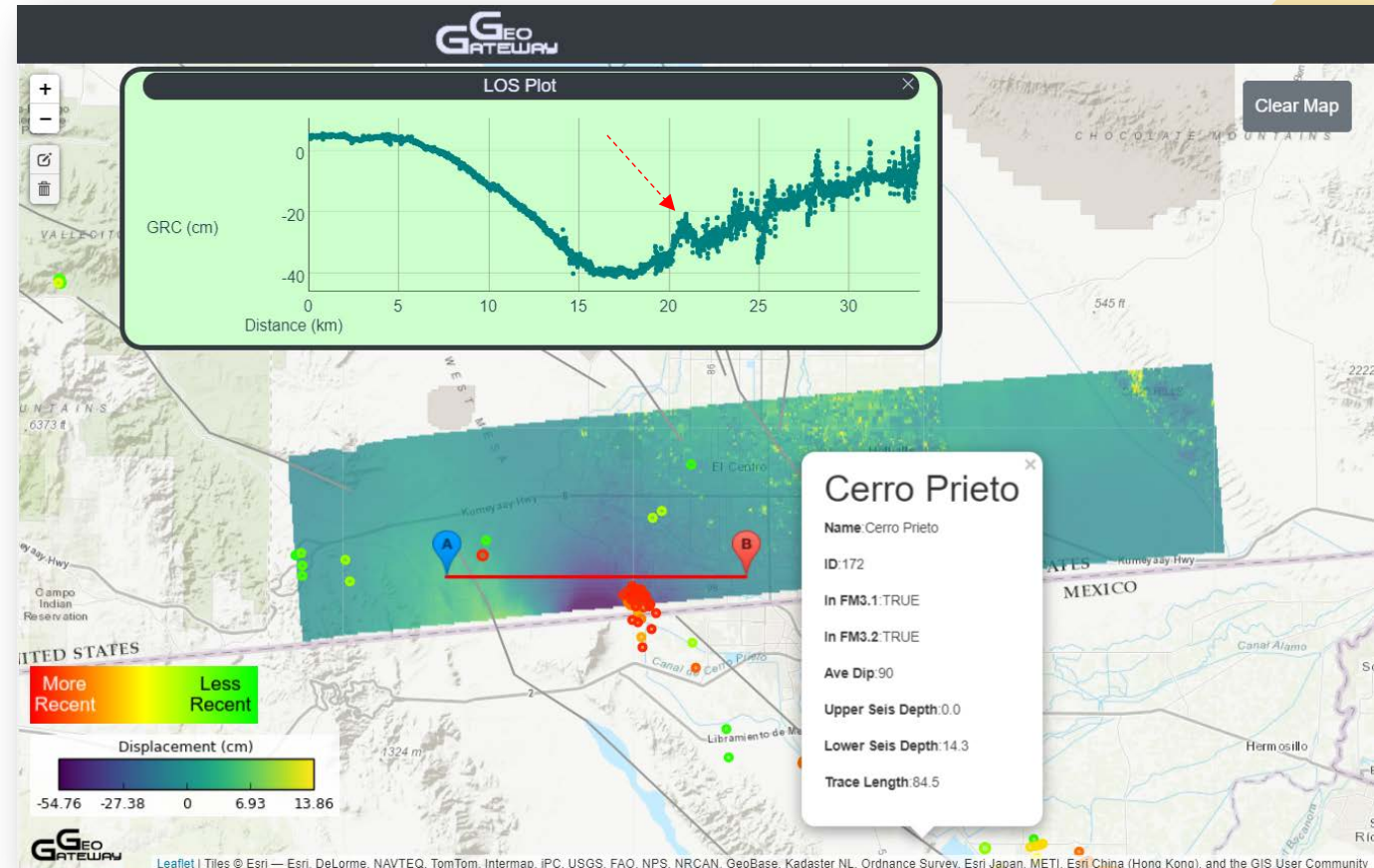
2. Insert start and end date and time →

3. Insert minimum and maximum magnitude →



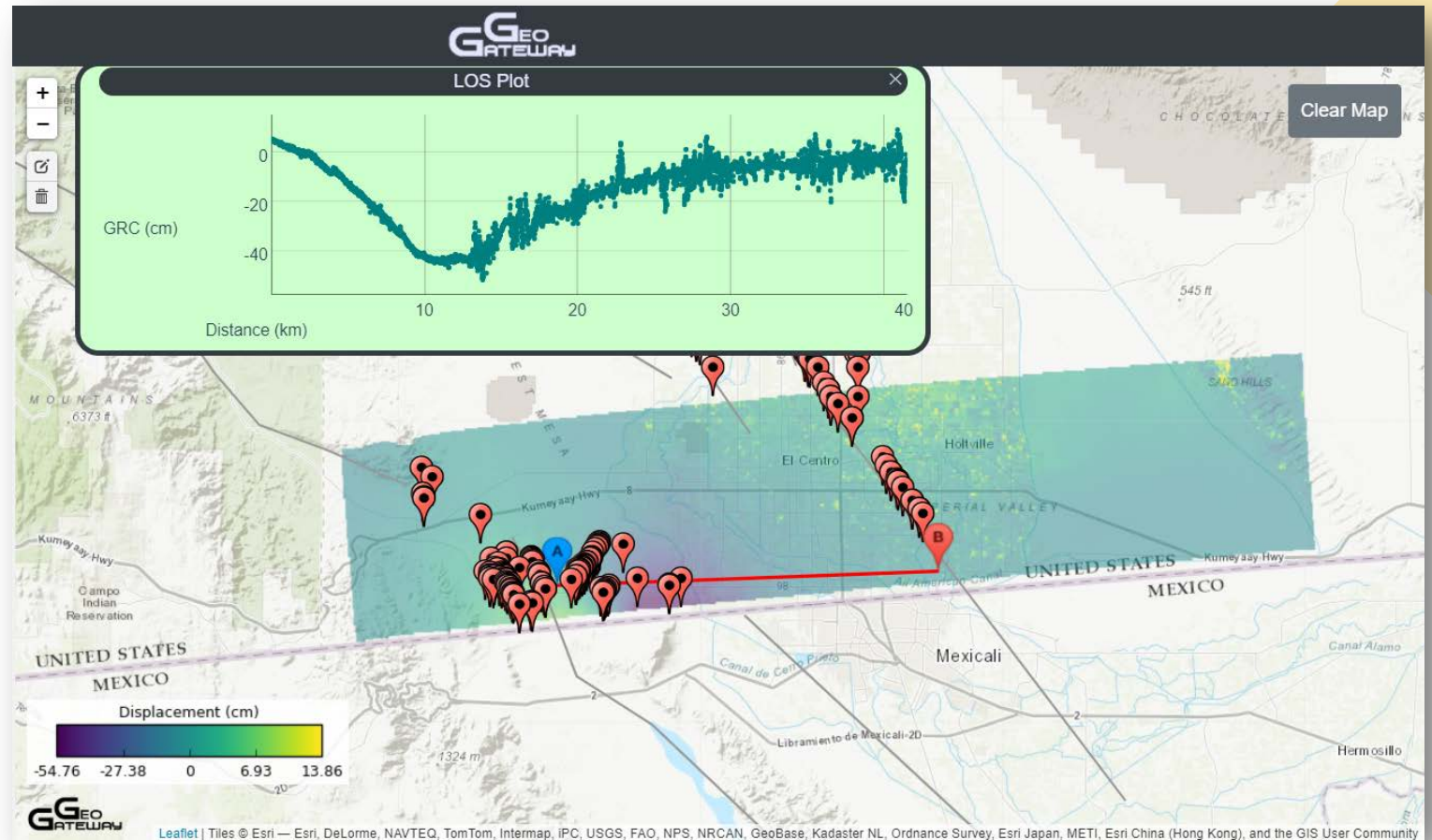
Multi-Method Layering (1-1)

- Method allows for users to explore the possible meaning of a feature in the interferogram that is not obvious at first glance.
- Figure displays
 1. UAVSAR
 2. Seismicity
 3. UCERF3 faults
- Ground range change is shown to have occurred across the two lobes



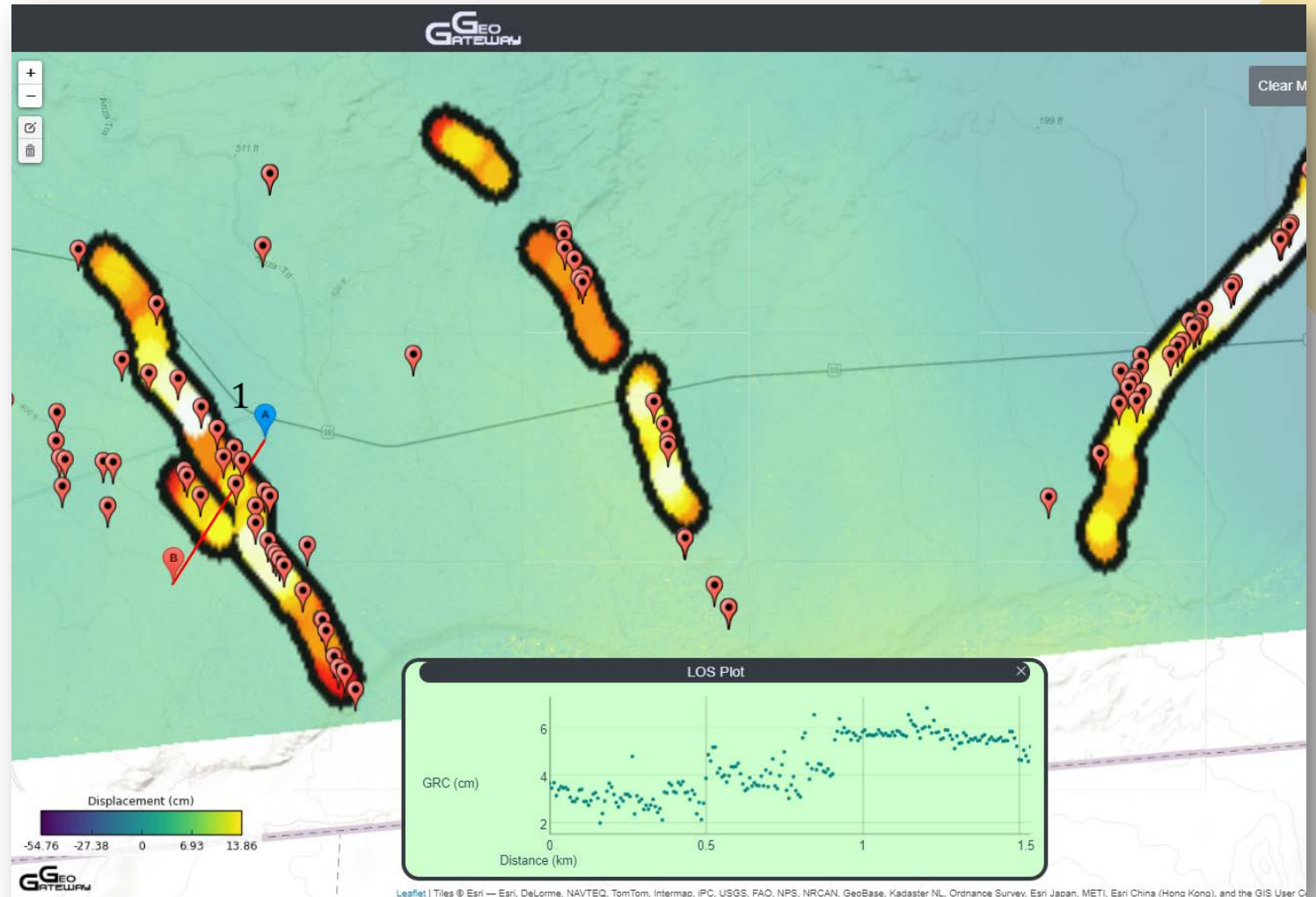
Multi-Method Layering (1-2)

- Figure displays
 1. UAVSAR
 2. (kml file) slip data waypoints for the El Mayor-Cucapah earthquake¹
- The overlay, suggests surface fracture



Multi-Method Layering (1-3)

- Figure displays
 1. UAVSAR
 2. Seismicity
 3. (kmz file) product of edge detection analysis
 4. (kml file) slip data waypoints for the El Mayor-Cucapah earthquake¹
- Edge detection product is used to find surface fractures
- LOS profile shows the detection of two close “edges” or two upward jumps in phase (at distance 0.5 and 0.9 km)
 - Indicates two separate surface fractures in close proximity



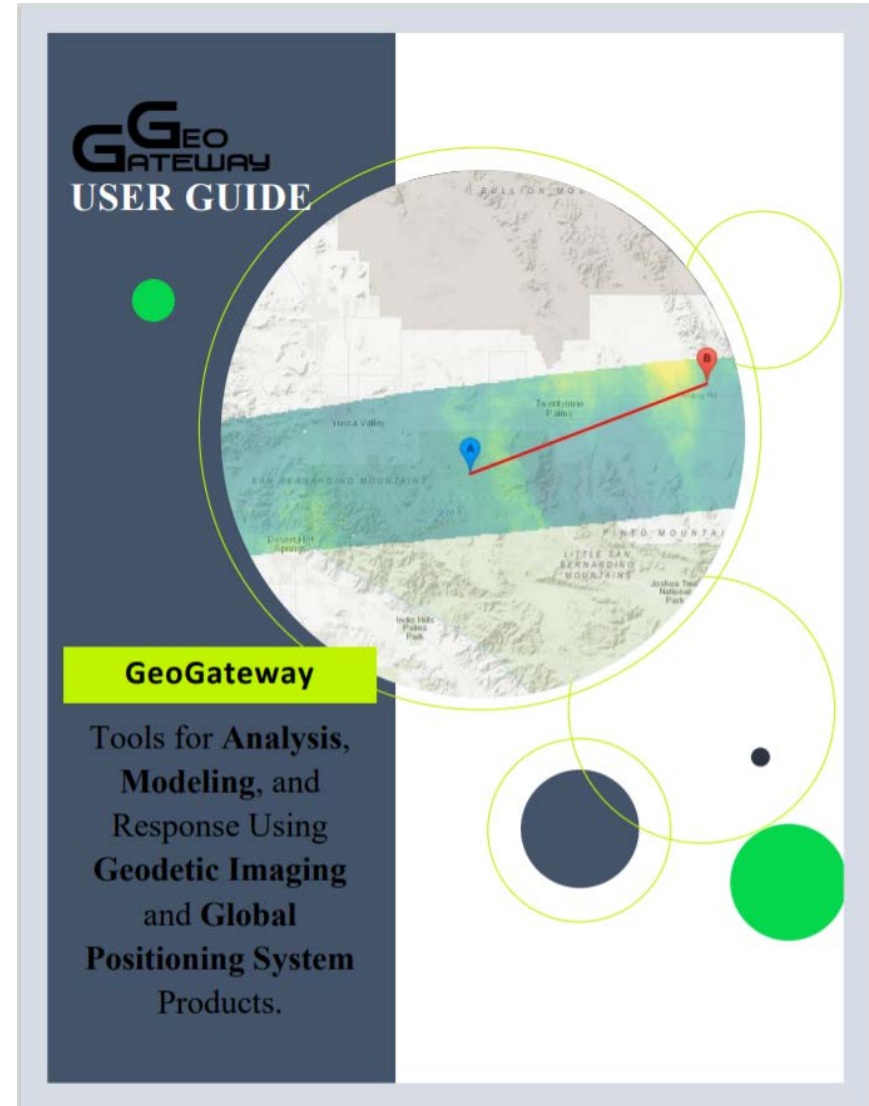
GeoGateway User Guide

Access website

- <https://geo-gateway.org/>
- https://beta.geogateway.scigap.org/geogateway_django_app/

User Guide

- Presents and describes the hosted datasets and models accessible on GeoGateway.
- The User Guide allows for users to gain hands on experience through the inclusion of sample exercises to complete



Conclusion

- GeoGateway is a data product search and analysis gateway for scientific discovery, field use, and disaster response.
- GeoGateway focuses on NASA geodetic imaging products from InSAR and GNSS integrated with earthquake faults datasets, seismicity, and models.
- Note that GeoGateway offers additional tools and functions available on the website as illustrated on the “Table of Contents” page from the user guide.

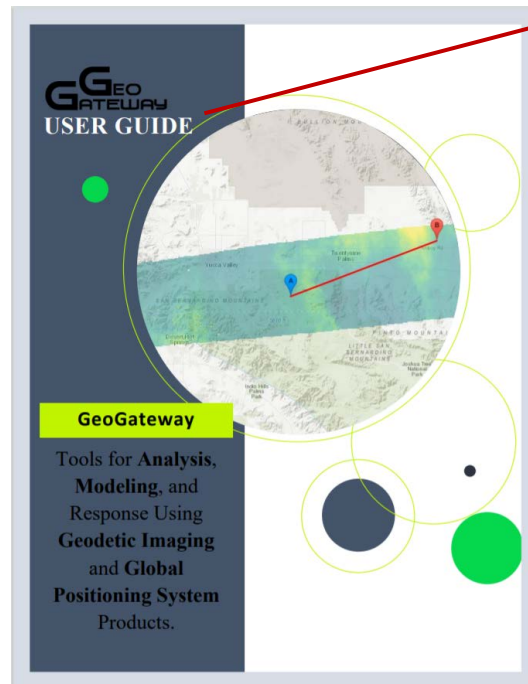


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Acknowledgments

GeoGateway Overview

GeoGateway Homepage

Map Tools

KML

UCERF3 Faults

Show State Boundaries

Show Coastlines

UAVSAR

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Global Positioning System (GPS)

Exercise (Produce GPS Velocities, Offsets, and Displacements)

Seismicity

Nowcast

Moment Magnitude Calculator

Exercise (Calculating Moment Magnitude)

Dislocation (Disloc)

Special Studies

Reset Tab

Help Tab

Citations



Thank you

